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## THE MESOZOIC SANDSTONE OF THE ATLANTIC SLOPE.

BY PERSIFOR FRAZER, JR.

THREE pamphlets lie on our table and constitute very important additions to the knowledge of the most puzzling of all geological formations, viz: that portion of the series lying between the Carboniferous and Cretaceous in this country. They are entitled as follows: "The Mesozoic Formation in Virginia, by Oswald J. Heinrich, Mining Engineer,"<sup>1</sup> "Notes on the Mesozoic of Virginia, by Wm. M. Fontaine,"<sup>2</sup> and "The Physical History of the Triassic Formation of New Jersey and the Connecticut valley, by Israel C. Russell."<sup>3</sup>

Without disparaging the merits of the other two, it must be said that the paper of Mr. Heinrich embraces more exact and positive knowledge of lasting value than either of the others. To complete the set, there should be added to the three just mentioned, a pamphlet of a few pages, by Persifor Frazer, Jr., on "The Position of the American New Red Sandstone" (read at the New York meeting of the A. I. M. E., Feb., 1877). In this paper there is a column of strata represented in a section across the Mesozoic belt from York to Dillsburg which will be of interest to those who have carefully read Mr. Heinrich's papers.

These contributions, taken together, are so valuable that a brief sketch of their separate contents will be of interest.

*Frazer's Paper.*—To take them in the order of their date, Frazer speculates upon the probable relationships of the various strata represented in his broad section with those of the European column, rather leaning to the belief that the rocks of Mesozoic age in Southern Pennsylvania, correspond with those which fill in the space occupied by the upper half of the lower Permian and the superior beds at least to the base of the Lias (*i. e.*, including the Rhætic beds). He says: "By this hypothesis the 'New Red' of York and Adams counties would reach from the middle portion of the lower half of the Dyas or Permian at least to the base of the Lias, including all the rocks attributed to the Trias and the beds below it, except the lower

<sup>1</sup> Read at the Phila. Meeting of the American Institute of Mining Engineers, Feb., 1878.

<sup>2</sup> American Journal of Science and Arts, Jan., 1879.

<sup>3</sup> From the Annals of the New York Academy of Sciences. 1878.

Rothliegende of the German scale." The thickness calculated by him for Prof. Rogers' section below Yardleyville is 51,500 feet, or nine and three-quarters miles, on the assumption that the bedding is normal, but this is regarded as delusive; and in a subsequent paper, by the same author, on "Some Mesozoic Ores" (Am. Phil. Soc. Proc., April 20, 1877), the wave-strewing hypothesis, by means of which Prof. Rogers sought to explain the inclined bedding is rejected as insufficient to account for all the phenomena.

*Mr. Heinrich's paper* is rich in facts, and is as remarkable for the absence of speculations as it is for the clear and logical standpoint from which he views the whole subject. Like Prof. Fontaine, he commences by describing the divisions of the formation into belts, but whereas Mr. Heinrich groups all the known exhibitions of Mesozoic, in Virginia, into four belts, Prof. Fontaine disposes of them in six belts. This latter arrangement does not seem to be necessary by reason of the small gaps between the various members of Heinrich's belts, and presents to the student not on the ground, manifestly greater inconveniences.

It is evident that even Heinrich's number of divisions is arbitrary, since a prolongation of the "Eastern" belt crosses the "Middle Eastern" at Taylorsville and joins the "Middle Western at Mount Vernon," but these separate ranges and the lines indicating them on his map, greatly assist the understanding of his minute details. His belts here follow.

- A *Eastern*.—Includes (1) the Petersburg deposits, and (2) the scattered masses of Mesozoic in Greenville and Brunswick counties, west of Hicksford and east of Lawrenceville.
- B *Middle Eastern*.—(1) Taylorsville deposits, (2) Springfield deposits, (3) Richmond deposits.
- C *Middle Western*.—(1) Aquia deposits, (2) Farmville deposits, from Mount Vernon to Fredericksburg.
- D *Western*.—(1) Potomac deposits, running from the Potomac river near Point of Rocks to the Wilderness, (2) Barboursville deposits, (3) James River deposits (near Scottsville), (4) Danville deposits, (5) Dan River deposits, on and south of the N. Carolina line.

Prof. Fontaine calls D 1 his "*New Jersey*" belt, D 3 his *Buckingham* belt, D 4 the *Pittsylvania* belt, C 2 (or a part of them) the *Prince Edward* belt, B 3 and a part of A 1 the *Richmond* belt, the southern portion of A 1 the *Petersburg* belt, which Prof. Fontaine describes as overlapping the Hanover area (*i. e.*, the

northern part of the *Richmond* belt [?]), whose uppermost beds pass into the lowermost of the Petersburg belt; and finally a seventh belt C 1 or the *Fredericksburg* belt. The area (or areas) covered by Mesozoic near Hicksford, which constitute the portions of Mr. Heinrich's A 2, Prof. Fontaine does not name, as he acknowledges that he has not visited them.

Mr. Heinrich's lucid and careful observation of the rocks which follow that of the boundaries of his belts, cannot be too highly commended. They are classed as 1, Conglomerates; 2, Sandstones, (*a*) Psephites or Siliceous and Feldspathic, and (*b*) Psammites or argillaceous matter with fine siliceous sand and some larger grains of quartz; 3, Slates and Shales; 4, Limestones; 5, Coal, (*a*) bituminous, (*b*) carbonite, (*c*) natural coke, (*d*) semi-anthracite; 6, igneous rocks; 7, accessory minerals.

The following six pages are devoted to a very good sketch of the general geological and stratigraphical characters of the formation, consisting of some useful information as to areas of drainage.

This third division of his subject ends with a succinct description of the results of diamond-drill boring, and the separation of the measures pierced, into seven groups. This is an exceedingly interesting portion of the paper, each division is so clearly distinguished from the others by striking characteristics as to seize the attention of the reader, who is too apt to forget that he sees so clearly because he is looking through Mr. Heinrich's eyes.

The next six pages are given up to a detailed lithological description of the section by inches. The third chapter closes with a summary of the results of investigation, and an observation (confirmed by the study of the measures near Dillsburg, Pa.) that the largest beds of trap, more frequently followed planes of bedding than planes of cleavage.<sup>1</sup>

The fourth division of his subject is devoted to the fossil remains of the formation, but here Mr. Heinrich confesses his inability to do justice to the subject, and Prof. Fontaine's information is fuller and has the additional advantage of his own excellent critical judgment, at least so far as concerns the flora.

The fifth and last division of Mr. Heinrich's report regards the economical products of the formation, prominent among which, of course, is the coal. Forty-nine analyses are given on p. 42,

<sup>1</sup> Frazer's Report. CC, Sec. Geol. Surv. of Penna.

about equally divided between the north and south sides of the James river. On the succeeding page six analyses are given of West Virginia coals, and three from the Richmond basin. On p. 44 is a table of the coal shipped from the basin in various years, and the whole concludes with a comparative table of the total amounts shipped from the principal basins in Pennsylvania and Maryland, and from the Richmond basin.

The illustrations are on two plates; Plate 1 contains a map of Virginia and part of North Carolina, south of the Potomac and east of the Blue Ridge with the lines of strike of the four belts into which the author has thrown the formation. The areas of drainage are well marked on this map, and the Mesozoic shaded.

Plate II contains, Fig. 1, a geological section of the bore hole; Fig. 2, a section of the beds on a vertical plane perpendicular to the strike; Fig. 3, a long section along the James river from Richmond to Scottsville, showing a synclinal between the western and middle western Mesozoic belts, a synclinal in the middle eastern, and a probable eroded anticlinal between the latter and the eastern, where the rocks seem to dip under newer formations to and under the sea.

In this connection it is almost a pity to note even trifling errors in Mr. Heinrich's paper. These are not confined to "elliptic" for elliptical (p. 7), "dolorite" for dolerite (pp. 17 and 37), square acres (p. 41), and other similar oversights of the proof-reader in correcting the text, but may be even found in the maps, as in "Ezoic" for Eozoic (Plate II Fig. 3, &c.). It was to be hoped that these defects would have been corrected in the volume of the Transactions of the Institute of Mining Engineers, in which the paper appears.

*Prof. Fontaine's Paper.*—After his grouping of the outcrops of the Mesozoic previously given, the author notices a deposit of stones which plays an important part in the NW. They are neither conglomerate nor boulders. Under this head is classed the "Potomac Marble," which is all of limestone fragments. In the Pittsylvania belt, however, the stones are the product of the granite and azoic rocks lying near.

In his description of the Richmond basin, Prof. Fontaine has probably been led into error by Rogers and Lyell, and in spite of his own notes, when he says, "The lower series, from three to five hundred feet thick, rests immediately on the granitoid gneiss,

which forms the floor of the basin. It contains all the coal found in the field."

Mr. Heinrich's careful column shows the lowest coal (not counting occasional bituminous and carbonaceous slates and sandstones) is found at 571 feet from the granite, the second at 600 feet, the third and fourth at 655 feet.

On this subject Mr. Heinrich's remarks (p. 35) are very instructive; for even the variable distance noticed by the author between the granite floor and the coal could scarcely account for so great a discrepancy. The faults in the Midlothian region are conceded by all, and Mr. Heinrich's section presents a very rational view of them; but why "borings cannot be relied upon" is not clear, though of course their value as guides decreases as the distance to the desired locality increases. One would suppose that they were all that could be relied upon.

A very interesting note in regard to certain varieties of the Potsdam strata, connect with this horizon the "compact vitreous quartzites and peculiar sandstones which have the grains of sand imbedded in a white, non-plastic, argillaceous matter," occurring a short distance above Harper's Ferry. Such rocks are indeed noticed elsewhere in positions entitling them to be considered Potsdam, but if by this are intended the quartz fragments imbedded in crystalline schist which make the high bluffs at Harper's Ferry on the Maryland side of the river, it is most interesting to note that they are strikingly similar to a great series composing the middle and western portions of the South mountain in Pennsylvania underlying the Orthofelsites and schists of probable Huronian age. Neither is the *Scolithus* a sure guide to the age of Potsdam in the opinion of all geologists.

The clay deposits and their supposed origin in "marshes within the Azoic area swept away in a general and extensive erosion," present certainly a new if somewhat hazardous line of dynamo-geological speculation, as also does the evident leaning of the writer towards a glacial movement to account for deposits of schists, granites, &c., on grit. It is noteworthy that Prof. Fontaine, Mr. Russell and others, each from his independent line of argument, arrives at the probability of a series of shallow and marshy beds to the south of the Mesozoic belts.

But the most novel explanation of the paucity of animal life in the Trias and Jura is that which supposes this time to have been one of great cold, when a huge ice sheet was advancing eastward

from the Blue Ridge, and its streams were feeding the Mesozoic areas. The ferns, cycads, &c., were furnished with a mild equable and moist climate by fogs from the Gulf Winds.

In this part of his argument it is difficult to follow the author, who would produce the glaciers by the cold winds sweeping east and north-east unchecked from the Pacific, while an "immense growth of coniferous trees covered the hills."

The problems with which Prof. Fontaine closes his paper, as to whether some of the drift in the northern States attributed to the Glacial period may not be much older; and whether there may not be drift deposits around the southern prolongation of the Appalachian chain, thus carrying an ice period into the far South to meet that of Prof. Agassiz in Brazil, are, as he says, well worth the attention of geologists.

In this paper the main points of interest are his belt of stones in the north-west and under the Catoctin range; his criticism of Schimper's determination of *Equisetum rogersii*, and his association of the ferns with the "Rhœtic" beds, or their contemporaries, his establishing the drift matter of Azoic fragments in clay as passing under the Cretaceous in Maryland, and his conclusions as to the great eroding action of a glacier previous to or coincident with the laying down of this drift.

*Mr. Russell's Paper.*—This is concerned nominally with the New Jersey Triassic, but includes observations on the New England and British American Trias as well. These rocks and the protecting action of their traps in the bay of Fundy are first considered, and the tidal action on the soft muds is afterwards referred to as a good example of the kind of action which produced these soft ripple-marked shales.

In endeavoring to give, from a few localities in New Jersey, a general idea of the characters of these shales and sandstones, it must be confessed that either their variety is singularly curtailed on the crossing of the Delaware into New Jersey, or many of the diverse representatives mentioned by Messrs. Frazer, Heinrich and Fontaine must here be classed under the same names.

Note A refers to a *south-westward* dip of the Trias just east of the Blue Ridge in Virginia. Fontaine gives this dip of his "New Jersey belt" as north-west, while Heinrich's section makes it east or south-east.

An italicised paragraph seems to claim novelty for the conclusion to be drawn from the fact that in New England the dip of

the Trias was south-east, in New Jersey north-west, while in Virginia and North Carolina the flexed structure was apparent.

This is more definitely stated on p. 11, where by the aid of a diagram it is insisted that the Triassic beds in New Jersey and Connecticut are but flanks of a great arch, the upper portions of which have been removed by denudation. The lithological evidence which the writer has accumulated in favor of this old view must be considered of value. Mr. Heinrich enunciates the same view, pp. 22 and 23, but on the ground of supposed analogy between the James and Hudson rivers, and indeed this structure has been accepted, if not with the foundation which Mr. Russell now gives to it, by many geologists from the date of the first Geological Surveys of New York and Pennsylvania to the present time.

Apropos of the writer's views of the possible agency of the traps as lines of displacement, it is worth observing that the largest and strongest dykes are found by Frazer (Report CC, Second Geol. Surv. of Penna., p. 325), and Heinrich, to follow planes of cleavage. This fact, as stated in the first part of the above, is proof that no large amount of displacement took place, since the strata themselves and other beds of trap parallel with the bedding, which pursue one direction, and those cleavage dykes, are as so many keys to structure, for *no* displacement of beds could take place without displacing these. Rogers' theory of the apparent great accumulation of the Mesozoic beds is not quite correctly stated, p. 9 (See note on this subject in Frazer's Position of Am. New Red, &c., p. 5).

The supposition that the conglomerate was derived from the accumulation of pebbles at the mouths of rivers, is not borne out by observations of this characteristic rock along the western border of the Trias in Pennsylvania, for it is uniform in character for long distances, and according to Fontaine, the most abundant stones in Virginia could not have come from a point further south than the Lower Silurian of Pennsylvania.

The two authors, Prof. Fontaine and Mr. Russell, unite in their belief that the Triassic conglomerate is an important landmark in the formation, but they ascribe its origin to very different causes. Whereas the former imagines it to have been carried to its present position on ice rafts, the latter ascribes it to the deposition of numerous river mouths pouring out into the sound in which the rocks of this age were being laid down.



The text accompanying diagram, p. 16, is not clear, and therefore cannot be criticised. The conglomerates of Maryland and Pennsylvania do seem to mark two horizons near the upper and lower parts of the New Red series.

Another oversight is the assertion that the bold line of bluffs composed of crystalline schists can be followed to a distance from Stony Point, N. Y., towards Virginia, sufficiently far to account for the conglomerate of that edge as its shore deposit. Over long stretches of this intervening distance the only high ground is made of these coarse and hard beds.

In the summary of reasons for accepting the theory of unity between the New England and New Jersey Mesozoic, considerations Nos. 3 and 4 seem to be new and valuable. No. 1 is valuable. No. 2 if true of New Jersey is not so in Pennsylvania, where on the very eastern margin of these beds, in York county (as on the western), the rock is a conglomerate (See Report C, Second Geol. Surv. of Penna., and CC *Ibid*, p. 264. Section 6. Frazer). No. 5 on the continuity of elevated ground, if well founded from Hudson river to New England, is not so for the entire course south-west.

In the discussion of the eruptive rocks Mr. Russell makes a very interesting point in regard to the crescent shape of the outbursts of trap in the New England and New Jersey Trias. In the former the horns of the crescents turn eastward, while the convex side is towards the west, whereas in the New Jersey series this order is reversed.

But it is evident that the trap rocks of New Jersey must differ materially from those in Pennsylvania, and also in Connecticut, because he states that "they are usually composed of an intimate combination" (*sic*) "with some form of feldspar." They very rarely contain any hornblende elsewhere, and in the large collection of traps from Pennsylvania there are but one or two, and these from exceptional localities in which hornblende has been detected. Another difference lies in the fact that it is not difficult to find the junction of the trap with the shales and sandstones that underlie them. In Pennsylvania this is always difficult and sometimes impossible.

Mr. Russell expresses the same view of the effect of a sinking of the floor, or what is the same thing, a rising of the eastern margin of the Mesozoic area, as that given in CC, 2d G. S. of Pa., pp. 269 and 271.

Page 28, he under-estimates the amount of thickness of rocks with which he has to deal if he employ the "usual manner" of calculating it, for Rogers' and Frazer's sections of the New Red in Pennsylvania make the total thickness 51,000 feet.

It is interesting in Note B to find Mr. Russell also testifying to the probable high and swampy character of the southern end of the Triassic estuaries.

Taking the papers together, we cannot fail to recognize that they form a very valuable and suggestive arsenal from which to draw weapons to renew the old attack on the New Red.

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## ON UNSYMMETRIC ARROW-HEADS AND ALLIED FORMS.

BY S. S. HALDEMAN.

**A**LTHOUGH most stone arrow-heads have a symmetric outline, a large collection will generally present variations which may be due to unsuitable material, to want of skill in the workman, to a love of variety, to intentional adaptation to a purpose, or to the consideration that a single barb might be sufficient. Love of ornament appears in the use of paint,<sup>1</sup> and in the selection of finely colored jasper and chalcedony for implements.

While irregularities would interfere with the function of arrows, all these objects are not to be regarded as arrow-heads, some of the larger kinds being for spears, while others are probably borers (Fig. 4), scrapers (Fig. 10) and knives (Fig. 8). As in civilized life, the workman whose kit is limited must make one implement serve the purposes of several. In fact, the enterprising explorer, Major J. W. Powell, brought from the Rio Virgen small knives of what would be regarded as arrow-heads if found detached, but which were fastened (with the gum of *Larrea mexicana*) in a notch in the end of a round wooden handle (see Fig. 1, p. 2, in Rau's Archæol. Collections of the National Museum).

The want of symmetry may be in the form of the body (Figs. 1, 3, 4, 8), in the shape and inequality of the barbs (Figs. 7, 11), and in the slight indication, or the absence of one of the barbs (Figs. 2, 5, 6, 8, 9).

A barb may be accidentally broken off during or after making,

<sup>1</sup> I have an arrow-head from Tennessee, one side of which is painted with a ferruginous red color.